TECHNICAL BULLETIN

SAFETY REQUIREMENTS FOR MAINTENANCE OF ELECTRICAL AND ELECTRONIC EQUIPMENT

HEADQUARTERS, DEPARTMENT OF THE ARMY

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REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

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Table of Contents

*This bulletin supersedes TB 385-4, dated 25 March 1983.

page

List of Illustrations

page

FOREWORD

This bulletin provides essential safety responsibilities for commanders of Army electrical and electronic maintenance facilities and precautions for personnel who maintain electrical and electronic equipment.

Maintenance personnel at all levels are responsible to know the safety requirements for each job they perform or supervise. Everyone who maintains electrical or electronic equipment in an Army facility should carefully read and understand the precautions contained in this bulletin.

Section I. GENERAL INSTRUCTIONS

1-1. Purpose

The purpose of this bulletin is:

a. To advise personnel who maintain electrical and electronic equipment in Army facilities of precautions that will help them to work safely;

b. To advise commanders and other officials who exercise control over Army electrical and electronic maintenance activities of their essential safety responsibilities; and

c. To advise installation commanders of various safety and health-related responsibilities in supporting electrical and electronic maintenance activities.

1-2. Scope

This bulletin covers safety precautions for all personnel - military, civilian, and contractor - who maintain electrical and electronic equipment in Army facilities. This bulletin also contains requirements for personnel safety indoctrination and training; medical surveillance programs; standard operating procedures; safety facilities; first aid; and coordination between maintenance activities and installation safety and health authorities that apply specifically to the maintenance of electrical and electronic equipment in Army facilities. This bulletin does not cover all safety precautions or responsibilities that may apply to any particular maintenance activity; rather, it includes only those that are widely applicable. When establishing safety policy, commanders should consult with their installation safety office for further guidance.

1-3. Definitions

For the purposes of this bulletin, the following definitions apply.

a. High voltage: A voltage exceeding 500 volts, DC or RMS.

b. Ionizing radiation: Electromagnetic radiation of sufficient intensity to cause ejection of electrons, exposure to which can damage human tissue.

c. Installation: An Army garrison, such as a post, camp. or station. Most installations contain elements that provide health, safety, fire protection, engineering, and medical services.

d. Maintenance: (Inspecting. testing, troubleshooting. repairing, and calibrating electrical or electronic equipment or components.

e. Maintenance activity: An Army organization whose mission includes maintenance of electrical or electronic equipments, such as an intermediate direct support unit, intermediate general support unit, or Army depot.

f. Non-conductive material: Material with an electrical resistance of at least one Megohm (1,000000 ohms).

g. Radiation controlled area (RCA). Any area to which personal access or occupancy is restricted and controlled for the purpose of protecting against exposure to ionizing radiation.

h. Radiation protection officer (RPO):. An official, appointed by the installation commander, whose primary task is to advise on the degree of hazards associated with ionizing and nonionizing radiation and on precautions for those hazards.

i. Radiation worker: A technician or other worker whose job responsibilities require his wearing a personnel dosimeter as stipulated in AR 40-14.

j. Radioactive waste. Unwanted material that is either radioactive or contaminated with radioactive isotopes. (Unwanted material that was previously contaminated but has since been decontaminated to a safe level is not radioactive waste; see TM 3-261 and AR 700-64.).

k. Radiofrequency (RF) equipment An equipment that propagates electromagnetic energy over any portion of the spectrum below 300 GHz.

I. Technician: An individual who performs maintenance on electrical or electronic equipment.

1-4. Responsibilities

a. Installation commanders will provide health, safety. fire protection, engineering, and medical services to enable maintenance activities to fulfill their safety responsibilities. Installation services include the assistance of radiation protection officers as required by AR 700-64.

b. Radiation protection officers will exercise the responsibilities listed in paras 4-2 and 5-4. Laser safety officers, if assigned. w ill exercise the responsibilities listed In para 4-3; on installations where laser safety officers are not assigned, the listed responsibilities will be discharged by the radiation protection officer.

c. Commanders or other officials who exercise operational control over maintenance activities will train

all technicians and supervisors on the requirements of this bulletin, prepare and post safety standard operating procedures. provide safety training, and enforce the safety precautions prescribed herein. They will ensure that emergency kits and safety facilities, tests, surveys. warning signs, etc. that are prescribed in Sections III through VII are provided as needed. When applicable. and in coordination with the installation occupational health officer. they will enroll their personnel in medical surveillance programs; such programs are required in certain cases for personnel who may become exposed to the following hazards:

(1) toxic fumes - see para 3-2*f* and 3-9 *b,*

(2) ultraviolet, visible, or infrared radiation, including laser radiation - see para 4-4 *a*;

(3) X Ray radiation - see para 4-1 *a*; and

(4) acoustical noise - see para 6-4.

d. Supervisors and technicians who maintain electrical or electronic equipment , ill observe the precautions prescribed herein and observe the warnings and precautions contained in the equipment technical manuals (TMs), including their test, measurement. and diagnostic equipment (TMDE) TMs.

e. Safety Is everyone ’s responsibility.

1-5. Standard Operating Procedures (SOPs)

Written SOPs are required for those frequently-performed hazardous operations so designated by the installation safety office. Additional SOPs will be prepared for maintenance of electromagnetic and radioactive equipments: topics are prescribed in paras 4-4 5-6, respectively. All SOPs should be reviewed annually and updated as needed. Each initial SOP and changes or updates thereto shall be coordinated with the installation safety office and with the appropriate installation technical advisor. such as the radiation protection officer, post electrician, etc.

1-6. Training

a. All personnel w ho work with electrical equipment. circuits. and transmission lines should be trained and certified in mouth to- mouth and cardiopulmonary resuscitation. Installation medical activities shall provide certified instructors. Navy assigned maintenance personnel should be trained as soon as, practical

b. Personnel will also be trained annually on the safety precautions in this bulletin and the safety SOPs, and the location of safety equipment to be used in emergencies; commanders or officials in charge of maintenance facilities will keep a record of this training for one year.

c. Personnel should receive additional training as needed to maintain proficiency in first aid and lifesaving techniques, including rescue and resuscitation.

1-7. Waivers

Major Army command (MACOM) safety offices are authorized to temporarily waive the requirements herein. Waivers shall not exceed six months duration. Commanders of maintenance activities may submit written requests for waivers through their installation safety office to their respective MACOM safety office. Each request must state the operating circumstances or conditions and necessitate a waiver. the steps being taken to eliminate those circumstances or conditions. and the precautions to be taken to ensure safety while the waiver is in effect.

1-8. Technical Assistance

a. Commanders and supervisors are encouraged to contact their installation safety office if they have questions about their safety and health responsibilities. The safety office can provide needed information and recommend practical measures to enable everyone to safely do his lob.

b. If further information or assistance is needed, commanders and supervisors may contact the US Army Communications- Electronics Command (CECOM) Safety Office to discuss procedures to implement the safety precautions explained herein or to determine the advisability of waivers. To do so, write to Commander, US Army Communications Electronics Command and Fort Monmouth, ATTN.: AMSEL-SF- SE, Fort Monmouth, NJ 07703 5024, or telephone DSN 992-0084 or (908) 532-008484.

1-9. Accident Reporting

Installation safety offices will report accidents that cause injury or equipment damage on DA Form 285, following the procedures prescribed in AR 385-40. Radiofrequency radiation and laser accidents will also be reported per Chapter 6 of AR 40-400. Accidents involving radioactive equipment will also be reported by telephone to the next higher headquarters and to the US Army Materiel Command as explained in para 5-11.

Section II. EFFECTS OF ELECTRICAL CURRENT AND FIRST AID FOR ELECTRICAL SHOCK

2-1. General

a. This section addresses the effects of electrical current on the human body and first aid for victims of electrical shock.

b. Severe injury or death can result when any part of the human body comes in contact with live electrical circuits. Technicians must be especially alert to the dangers of exposed circuits, terminals, power entry panels, and the like.

c. The electrical phenomenon that injures and kills is CURRENT; the force that causes current to flow is called VOLTAGE. Voltage ratings are normally assigned to live electrical circuits, power supplies, and transmission lines. YOU SHOULD CONSIDER ALL VOLTAGES OF 30 VOLTS OR MORE TO BE HAZARDOUS. Under certain conditions, even a low voltage can cause sufficient current to flow through the body to cause injury or death.

2-2. Physiological Effect of Current Flow

a. The physiological effect of current flowing through the human body is related to the following factors:

(1) The path of the current through the body.

(2) Magnitude of the current.

(3) Duration of the voltage shock or discharge that causes the current to flow.

(4) The frequency of the voltage if alternating current.

(5) Susceptibility of the heart to the current and to repeated shocks.

b. Table 1 displays the physiological effects of current for different magnitudes and frequencies of the applied voltage. At any specific frequency, rated in hertz (Hz), the current's effects become more severe as its magnitude increases. The same magnitude of current, measured in milliamperes (ma), will cause more severe effects at the lower frequencies than at the higher frequencies.

c. The magnitude of the current is a function of both the applied voltage and the body's resistance and is determined by Ohm's Law: I = E/R, where I is the current flowing through the body, E is the voltage applied to the body, aid R is the body's total resistance to the current flow, measured in ohms. Total body resistance, R. is the sum of contact (skin) resistance and internal body resistance. Contact resistance varies between 100 and 500 ohms: wet skin presents lower resistance to voltage than dry skin; a larger contact area of skin presents less resistance than a small area. Under high voltage, contact resistance may break down and become negligible. Internal body resistance normally varies between 200 to 1000 ohms: its magnitude depends in a large measure upon the frequency of the applied voltage: the lower the frequency of the applied voltage. the lower the effective internal body resistance, and the higher the current flow around and through the heart and other vital body organs. In particular. the effects of any specific magnitude of current will be more severe at 60 Hz than at radio frequencies.

NOTE

Alternating current (AC) tends to concentrate near the body's surface because of the phenomenon of "'skin effect". The higher the frequency of the AC voltage source, the more the current will tend to flow in or near the skin and away from internal body organs. Whereas the direct current (DC) resistance is a constant for a given set of physical conditions, the body's effective resistance to AC increases with frequency. A technical description of skin effect is in MIL-HDBK-41A, Volumn 1, page 5-3.

d. The current's effect becomes more severe with the length of time that it flows through the body; a prolonged current flow can cause severe internal burns, collapse, unconsciousness, or death. Therefore. contact with a voltage source that may create a current above the let-go threshold is particularly dangerous.

2-3. Lethal Effects of Electrical Current

The lethal effects of electrical current on the human body are summarized below. The current values shown here and in Table 1 are approximations different people have different thresholds of tolerance and there is not a precise value for a lethal dose

a. Currents flowing through the heart can cause ventricular fibrillation: rapid contraction is of the muscle fibers of the heart and a lack of synchronization between the heartbeat and i the pulse. Unless arrested.

fibrillation may cause death within a few minutes. It is impossible to precisely know, either the magnitude or the path that electrical current will take in any human body or whether that current will pass through the heart. However, be aware :hat 600 ohms of body resistance in contact with 120 volts will produce a current of 0.2 amperes, ,somewhere here in the body. The threshold for fibrillation can be as little as 0.1 ampere.

i. Currents flowing through the chest, head, or nerve centers that control breathing can inhibit respiration and bring on suffocation. Paralysis of the respiratory organs may last for a considerable amount of time, even after the current is interrupted. In such event, artificial resuscitation must be promptly applied; see para 2-4.

c. High currents can cause the heart to stand still, produce fatal damage to the central nervous system, produce deep burns, and raise the body temperature to cause immediate death.

d. Victims who have been revived sometimes die suddenly and without apparent cause. Reasons attributed to sudden death are aggravation of preexisting conditions, hemorrhages that affect vital nerve centers or produce other effects to the nervous system, burns, and other complications resulting from the shock.

2-4. First Aid for Electrical Shock Victims

For victims of electrical shock, prompt and appropriate first aid may mean the difference between life and death or between temporary and permanent injury. Many victims of electrical shock can be saved with proper and continued first aid. The importance of continuing cardiopulmonary resuscitation (CPR) In apparently dead victims cannot be overemphasized. Complete recovery of such Victims has been achieved even after minutes of stopped or fibrillating heart action and cessation of breathing If you work with electrical equipment, you must know how to apply CPR as described in FM 21-11 and be prepared to react to an electrical shock victim When you see someone in trouble with an electrical conductor, this is what you must do:

a. FIRST: remove him from the source of current. When you sec that the victim can't let go of a live conductor, IMMIEDIATELY KILL THE POWER OR PULL HIM AWAY, WHICHEVER IS FASTER. If you have to pull him away, DON'T TOUCH HIM DIRECTLY or) you may place yourself in the circuit and also become a victim. Instead, pull or pry him loose with a dry rope, wooden stick, or an insulated pole.

b. After you've removed the victim safely away from the live conductor, seek medical help and, if necessary, apply CPR and continue to do so until you are relieved by trained medical personnel.

NOTE

AR 405 stipulates that personnel who may be required to perform first aid must receive approved first-aid training as determined by the local medical authority: see para 1-6*a*.

Table 1. Thresholds of Physiological Effects

Physiological Effect	Current (milliamperes)					
	Direct Current		60 Hz		10 KHz	
	Men	Women	Men	Women	Men	Women
Slight sensation on hand	1.0	0.6	0.4	0.3	7.0	5.0
Perception threshold. Medium	5.2	3.5	1.1	0.7	12.0	8.0
Shock. No pain or loss of muscular control	9.0	6.0	1.8	1.2	17.0	11.0
Painful shock; slight loss of muscular control	62.0	41.0	9.0	6.0	55.0	37.0
Let-go threshold, median; painful shock	76.0	51.0	16.0	10.5	75.0	50.0
Severe shock. difficult breathing. near total loss of	90.0	60.0	23.0	15.0	94.0	63.0
muscular control						
Ventricular fibrillation: (Probably fatal)			100	100		

NOTE: The threshold values In this table are approximations of average human tolerances Actual tolerances vary from person to person.

Section III. ELECTRICAL SAFETY REQUIREMENTS

3-1. General

This section summarizes essential electrical safety precautions and facility requirements for maintaining any type of electrical and electronic equipment.

3-2. Electrical Safety Equipment and Facilities

a. Emergency equipment.

(1) Each maintenance facility in which personnel are exposed to 70 volts or higher should maintain safety boards in accessible and conspicuous locations; the safety boards will contain items for use in electrical emergencies and for first aid to electrical shock victims. If a safety board is impractical, a kit of emergency items of equipment must be otherwise provided and conspicuously identified. These items must be reserved for emergencies; they may not be used for routine purposes. The safety board or emergency kit should be inspected monthly to ensure that all items are available and in good condition. Safety boards should be made to be easily recognized and familiar to personnel; a list of recommended emergency items and suggested coloring and marking is provided in para 3-21.

(2) In work areas where circuits breakers are easily accessible, are prominently labeled to allow rapid shutdown of equipment in an emergency, and where SOPs call out the use of these circuit breakers, a safety board may not be necessary. In such cases, commanders or other officials in charge of maintenance activities should contact the local safety office for a determination.

(3) Mobile maintenance facilities and transportable maintenance shelters that are not readily accessible to a medical facility should be provided with a General Purpose First Aid Kit, NSN 6545 -0922-1200.

NOTE

AR 40-5 stipulates that the local medical authority must approve the contents, intended use, and maintenance of all first-aid kits and that personnel who may be required to perform first aid must receive approved first-aid training; see para 1-6 a.

b. Flooring, and work surfaces. Flooring and work surfaces must be constructed from non-conductive materials. In work areas with exposed voltages of 30 volts or more, the resistance of flooring and work surfaces must be at least one megohm per kilovolt. If necessary, additional floor insulation, such as rubber mats or wooden platforms that conform to MILM-15562, will be provided to achieve this level of resistance. New facilities will be tested before their initial use and annually thereafter to verify that they meet the resistance requirement; a proper method for resistance testing is explained in para 3-22. Test data and corrective actions, if any, will be recorded and kept on file for two years

NOTE

The wearing of non-conductive safety shoes is recommended for personnel who work with dangerous voltages. However, flooring must meet the one megohm per kilovolt resistance requirement whether or not safety shoes are used.

c. Circuit panels. Circuit panels must be prominently located and easily accessible. Main circuit breakers must be prominently labeled.

d. Facilities used for battery charging. All facilities that are used for charging of batteries shall be well ventilated and equipped with a emergency eye wash and a shower that is readily accessible.

NOTE

Emergency eyewashes and showers must be certified to meet the requirements of American National Standards Institute (ANSI) Standard Z358.1.

The wash facility must be a type that can be easily operated by a blinded person and must function during the coldest time of year; it should be tested week. See para 3-17 for specific safety requirements for battery charging.

e. Warning signs. Maintenance areas that have exposed voltages from 70 to 500 volts will be posted with yellow and black CAUTION signs. Areas that have exposed voltages exceeding 500 volts will be posted with red, white, and black DANGER signs. See AR 385-30 for details. Appropriate warning signs will be posted in areas where toxic fumes are known to exist; see para 3-9 for precautions associated with toxic selenium and cadmium fumes. Warning ,signs may be required in the vicinity of high-intensity visible light (para 4-1 *b*); X-Ray producing equipment.

(para 4-4 *e*): laser devices (paras 4-1 *c* (3) and 4-7 (11)); radiofrequency (RF) equipments (para 4-8 *d* (7)), and radioactive materials (para 5-7 *e*).

f. Use of silver solder containing cadmium. The use of silver solder containing cadmium is prohibited unless approved by the MACOM safety office. In such cases. adequate ventilation and other appropriate industrial hygiene controls must be provided to prevent the inhalation of toxic cadmium fumes. Personnel involved must be included in a medical surveillance program: see para 3-9. (See para 1-7 for instructions on requesting a waiver from the MACOM safety office and para 1-X for information on technical assistance.)

g. X-radiation (x-ray) hazards. Electrical equipment, including TMDE, that contain 10,000 volts or more may emit harmful x-rays. See para 4-9 for precautions on the use or maintenance of equipments that emit x -rays.

h. Ground-fault circuit interrupters (GFCIs).

(1) In order to perform as intended, GFCIs must be correctly Aired. To ensure correct wiring, officials in charge of maintenance facilities should verify that the following initial test has been or is performed on each GFCI-protected circuit. First, plug an electrical equipment, such as a lamp or a radio, into the GFCI outlet. turn it on, and verify that it operates (receives power). Then, press the "Push-to-Test" button on the receptacle and verify that the equipment turns off and remains off, indicating that power has been removed. Finally. press the "Reset" button on the GFCI and verify that the equipment operates. If pressing the "Push—to Test" button does not interrupt power to the equipment. then ask your installation or facility electrician to check to see if the GFCI is correctly wired.

(2) In addition to this initial test, the "Push-to Test" button should be tested monthly.

3-3. Safety Precautions When Working with Live Circuits

Technicians and other personnel will observe the following precautions when working with live electrical circuits.

a. Make sure that at least two persons are in the area at all times when work is being performed on exposed live circuits, carrying 30 volts or more. This ensures that one person will be available to assist the other in case of an accident.

b. Before starting work on live circuits, remove all exposed metal object from your body: bracelets. watches, rings, dog tags, etc. Know the location of your emergency rescue equipment and make sure that it is available.

c. Be alert to the position of your hands, feet, and body when working with energized circuit boards, power cables, transmitter output terminals, transmission lines, antennas, or any other kind of live circuit. Many electrical shock accidents during maintenance occur when one of the technician's hands contacts a live (hot) circuit while the other hand is touching a grounded conductor, such as a chassis, rack frame, or cable raceway. Make a habit of keeping one hand free; most experienced technicians have learned to use only one hand for probing while keeping the other hand in a pocket or behind the back. When you need both hands for such tasks as voltage measurements, firmly grasp the insulated leads and place them on the test points. When measuring high voltages, follow the procedures outlined in para 3-3 *g* below.

d. Never handle energized electrical equipment when your hands, feet, or body are wet or perspiring or when you are standing on a wet surface.

e. If a maintenance procedure requires you to touch live electrical components, such as checking for overheated motors, use the back of your hand. If an accidental shock were to occur, your hand would pull away rather than uncontrollably grasp the equipment.

f. Never put your hand on or near a capacitor or capacitor bank or any wire or conductor attached to a capacitor unless and until all the capacitors are grounded and a shorting bar or grounding stick is in place: the procedures for safely discharging capacitors are explained In para 3-5.

g. Before you attempt to measure high voltages (500 volts or more). get a second person to assist and follow these steps:

(1) Turn off all power to the equipment to be tested.

(2) Discharge all high-voltage capacitors by following the procedures in para 3-5.

(3) Attach a secure temporary ground to the equipment to be tested.

(4) Attach plug-in or clip-on probes to the test points: hand held probes are not allowed for high-voltage measurements.

(5) Remove the grounding stick that you installed in step (2).

(6) Turn on the power and let the other person take the readings. Do not touch the test instruments while the power is on.

(7) Turn off the power.

(8) Again discharge all high-voltage capacitors by following the procedures in para 3-5.

(9) Remove the test leads.

(10) If another measurement is required, repeat (I) through (9).

h. In the event that your electrical service fails while power is being applied to either the equipment being maintained or TMDE, you should (1) open the circuit breakers of the power source and (2) turn all equipment and TMDE power switches to the OFF position. After service is restored, check to be sure that the equipment switches are in the OFF position before you close the circuit breakers.

i. When working near live antennas and other sources of propagating RF energy, avoid contact with surrounding metal objects, such as railings, inactive antennas, equipment shelter walls, vehicles, aircraft, etc. If possible, ground all such objects that have not been grounded.

NOTE

Grounding reduces but does not eliminate the risk of electric shock; see para 7-2.

3-4. Insulation Leakage

Promptly repair any electrically-powered equipment that produces a perceptible "tingle", including power tools and TMDE. The tingle that you feel is current leaking through the Insulation. Over time, insulation leakages become progressively worse and can become hazardous, especially when you make contact with conductive surfaces within reach, such as bench supports, exhaust hoods, pipes, or damp floors. Do not rely on grounding for protection against a defective circuit or wiring.

3-5. High-Voltage Capacitors

Fully discharge all high-voltage capacitors before starting work on or near the equipment in which they are contained. Some equipments have shorting bars installed that automatically discharge the capacitors when the chassis is opened. For an equipment that does not automatically discharge, use grounding sticks for this purpose and leave them in place while maintenance work is being performed; this will prevent recharging of the capacitor from dielectric effect. A typical grounding stick is illustrated in fig 3-1. The grounding stick conductor should be a solid copper hook of at least 3/16 inch diameter; spring clips are not recommended for attachment of the grounding stick to a capacitor terminal. The grounding stick handle may be made from rigid plastic or dry hardwood painted with clear shellac.

3-6. Cathode-Ray Tubes (CRTs)

Be aware that CRTs contain voltage hazards and can cause cuts and eye damage from implosion. Before handling an exposed CRT., short the high-voltage terminal to ground. Avoid scratching or damaging the CRT as this can cause implosion. While handling CRTs, wear protective eyewear (such as safety glasses with side shields, industrial safety goggles. or a full face mask), leather gloves, and leather aprons.

3-7. High-Voltage Vacuum Tubes

Before starting maintenance on any, equipment that contains high voltage vacuum tubes used as rectifiers (e.g. 1B3GT, 1V2), be sure that the filaments are grounded. While the power to the equipment is OFF, use an ohmmeter to check the filament ground circuits.

3-8. Electron Tubes Containing Radioactive Material

a. Radioactive material is contained in certain electron tubes, including spark gap, transmit/receive, glow lamp, voltage regulator, and cold cathode tubes. Radioactive tubes are normally so identified and marked with a radiation warning symbol. DO NOT PERFORM MAINTENANCE ON RADIOACTIVE TUBES unless you are an approved radiation worker as defined in para 1-3 *i* and you are working in a designated radioactive equipment maintenance facility or unless so directed by the installation radiation protection officer (RPO). If a radioactive tube becomes broken, IMMEDIATELY notify the RPO or the installation safety office and follow their instructions; see para 5-2 *i*.

b. In the event that you find an unmarked tube that you suspect may contain radioactive material, follow the procedures described in para 5-2 *k* (2). Unless and until the tube is positively identified not to contain radioactive materials, handle and store it as directed by the radiation protection officer or the installation safety office.

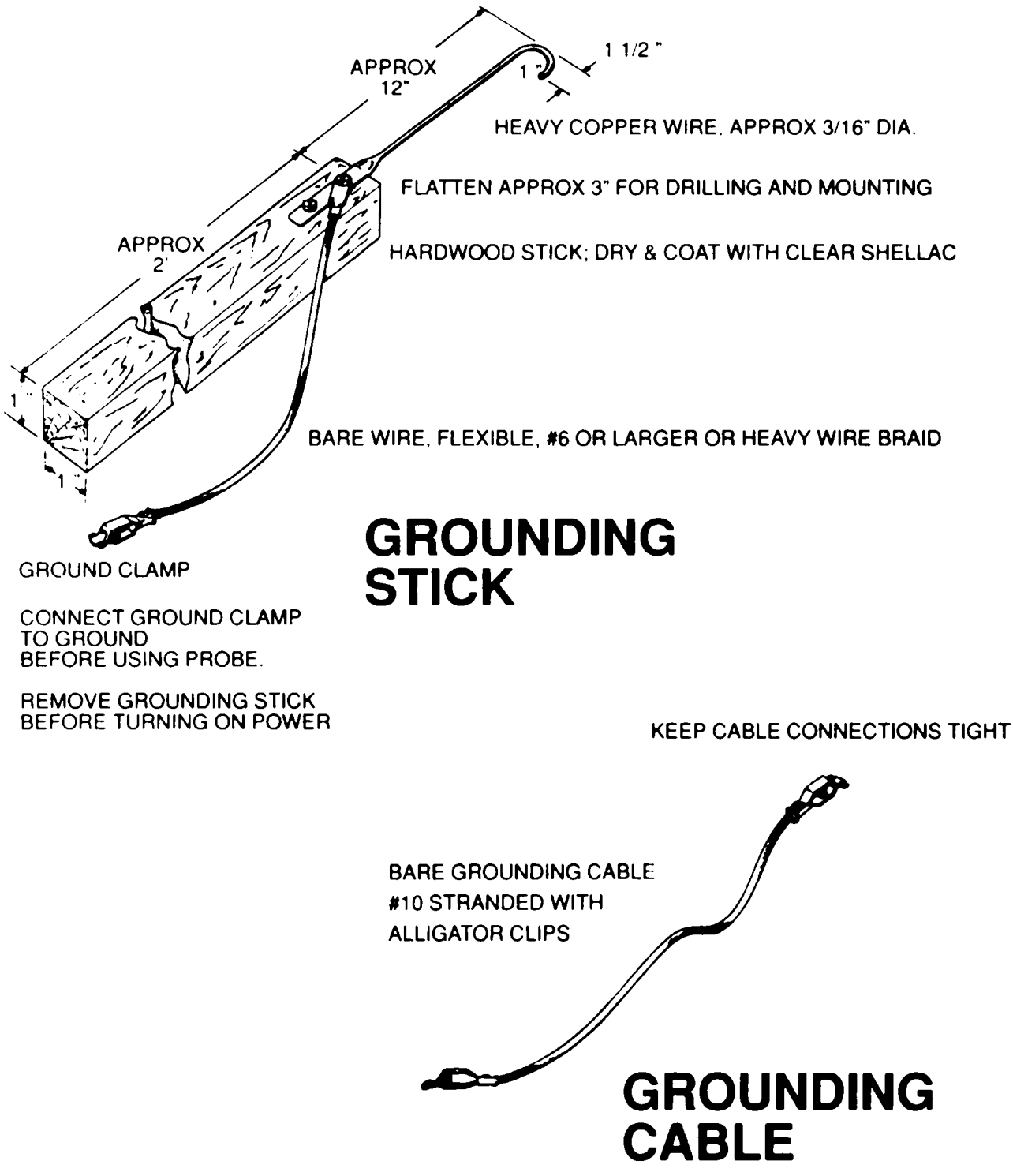

Figure 3-1. Grounding stick and grounding cables, fabrication diagram

3-9. Health Hazards of Selenium and Cadmium

a. During soldering, selenium and polyfluoride dielectric material, such as Teflon, which are used in rectifiers and other semiconductors. can release toxic fumes. Officials responsible for maintenance operations that might produce selenium fumes should have their operations surveyed by the installation Industrial hygienist. If inhaled, selenium fumes can cause severe breathing difficulties. These fumes have an odor similar to horseradish. If you detect this odor, turn off all power and evacuate the area until the fumes are ventilated. Skin contact with heated materials that contain selenium compounds can cause skin bums, rashes, or eye irritation. Therefore. wear protective gloves when handling heated selenium semiconductors.

b. Cadmium is contained In some low-temperature silver solders and in certain metals to increase hardness and protect against corrosion. When heated. these materials can produce toxic fumes which will irritate the nose and throat and can cause, after a delay of several hours, coughing, chest pains, sweating, chills. shortness of breath, or weakness. Repeated or prolonged exposure can cause loss of sense of smell, emphysema, kidney damage. or anemia. Inhalation of a sufficient amount of cadmium, even over a short term, can cause death. Do not allow anyone to solder with materials that contain cadmium unless adequate ventilation systems are installed and properly functioning. If you work with silver solder containing cadmium, you must receive periodic medical surveillance: see para 3-2*f*.

3-10. Removal of Vacuum Tubes

Remove vacuum tubes by hand or with tube pullers. Do not use knives, screwdrivers, or other thin-edged tools.

3-11. Replacement of Fuses

Before replacing fuses, disconnect the power and deenergize the circuits. Except for replacing fuses in holders that are designed to be removed by hand, use fuse pullers to remove and replace fuses. Do not replace a blown fuse with a fuse of a higher current rating or with a metal substitute: make sure that fuses are rated for the voltage to be applied to the circuit. Do not use a higher-rated fuse to correct a fault. Do not use a slow -blow fuse to replace a fast-blow fuse. and vice versa. Since a blown fuse is often tile result of a circuit fault, check the circuit before replacing the fuse.

3-12. Alignment Tools and Hand Tools

Use only non-conductive alignment tools and hand tools with insulated handles in and around electrical or electronic circuits.

3-13. Soldering

a. Turn off soldering irons or place them in covered holders when they are unattended. Wear safety glasses or industrial safety goggles when soldering or unsoldering wires or components that are under tension: molten solder may scatter when the wires or components break loose.

b. Do not use silver solder containing cadmium unless a waiver has been granted by the MACOM safety office and adequate ventilation and other appropriate Industrial hygiene controls are provided and properly functioning to prevent the inhalation of toxic cadmium fumes. If you work with silver solder containing cadmium, you must receive periodic medical surveillance. Cadmium health hazards are explained in para 3 -9 *b*.

3-14. Bench Tops

Limit the number of electrically powered items, including TMDE. placed on the bench top and turned on during any maintenance operation to those necessary to perform the operation. Do not work with electrical equipment, tools, or TMDE on any bench that has a conductive (metal) surface.

3-15. Circuit Panel

Be aware of the location of the circuit panel so that equipment and TMDE may be quickly shut off in an emergency .

3-16. Cables and Connectors

Turn off power before connecting or disconnecting cables to any power or signal source of 30 volts or more. Before using any cable or connector, inspect it for worn spots, breaks, cracks. and bent or broken pins; if you find any, replace or repair it before proceeding. Always connect and disconnect cables by grasping the end connectors: never disconnect by pulling the cable leads.

3-17. Battery Charging

a. Before charging batteries, make sure that the area is well ventilated, clean, uncluttered. and free from unnecessary tools or conductive materials that could accidently contact and short-circuit the battery terminals.

b. While filling storage batteries, wear acid-resistant gloves. chemical-splash goggles. rubber aprons, and

rubber boots with non-slip soles. If available, use a fume hood.

c. While working around batteries that are being charged, wear chemical-splash goggles or a full face shield to protect against sprayed electrolyte.

d. Know the location of the nearest eye wash and shower. If battery electrolyte is spilled on your skin or eye. IMMEDIATELY FLUSH THE AREA WITH A LARGE QUANTITY OF WATER AND CONTINUE FLUSHING FOR FIFTEEN MINUTES. Even a slight delay call mean loss of sight if the electrolyte, whether acid or alkaline, contacts the eye. Immediately afterwards, go to the nearest medical treatment facility to get care that will be needed to prevent further damage.

e. To avoid back injury, use appropriate mechanical aids to lift large storage batteries. See para 6-2 *f* for precautions for foot protection.

3-18. Guards and Barriers

Do not remove any built-in guard or barrier that protects against accidental contact with a dangerous voltage within an equipment unless its removal is necessary to test a circuit. If you must remove a guard or barrier, replace it immediately after you complete the maintenance task.

3-19. Interlocks

Never bypass an interlock that is designed to cut off power to a unit containing a dangerous voltage when access doors are opened except for interlocks that contain a bypass switch and only when power is needed for open-door testing. Regardless of the circumstances, do not bypass any interlock that does not have a built-in bypass capability. Do not rely on interlocks for disabling power; always turn off the main power sand disconnect the main power cord before opening an equipment.

3-20. Vehicle Antennas

Before moving a vehicle, make sure that mounted whip antennas can clear power lines. If practical, remove or tie down the antennas before moving the vehicle.

3-21. Emergency Kits

a. The following items are recommended for emergency kits; check with the installation safety office for other recommendations.

(1) Rope, halyard, 3/8 inch, 25 feet, NSN 4020-00-174-3031.

(2) Gloves, rubber, 3000 volts, sizes 9 through 12, NSNs 8415-00-782-2140/41/42/43.

(3) Grounding stick, fabricated locally, as shown in fig. 3-1.

(4) Safety hook, fabricated locally, as shown in fig. 3-2.

(5) Flashlight, Army issue.

(6)Grounding cables, AWG #10 stranded, with clips, fabricated locally as shown in fig. 3-1.

(7) General Purpose First Aid Kit, NSN 6545-00-922-1200; see para 3-2 *a* (3).

(8) Resuscitators and snake bite kits of the types that are approved by the local medical authority.

(9) Emergency procedures and telephone numbers: ambulance, hospital, doctor, etc.

The items in the kit should be checked monthly and replaced as needed.

b. Safety boards that are used for storing and displaying emergency kits should be painted white with a two-inch green border. Likewise, it is recommended that the board title contain white letters on a green rectangular background and the positions of the items be designated in black letters on a white background.

3-22. Surface Resistance Test Procedure

The resistance of floors and work surfaces should be measured as follows. Select a high-resistance measuring instrument, such as the Biddle-Grey megohm meter, model no. 210359, NSN 6695-01-158-0747. Connect one electrode of the measuring instrument to the facility's certified ground. Connect the other electrode to a five-pound block of metal that has a contact surface of five square inches of good conducting material. Attach a non-conductive strap or handle to the block (see fig. 3-3). Apply voltage; pull the block along all points of the floor or work surface under test to verify that the complete surface meets the minimum resistance requirement of one megohm per kilovolt.

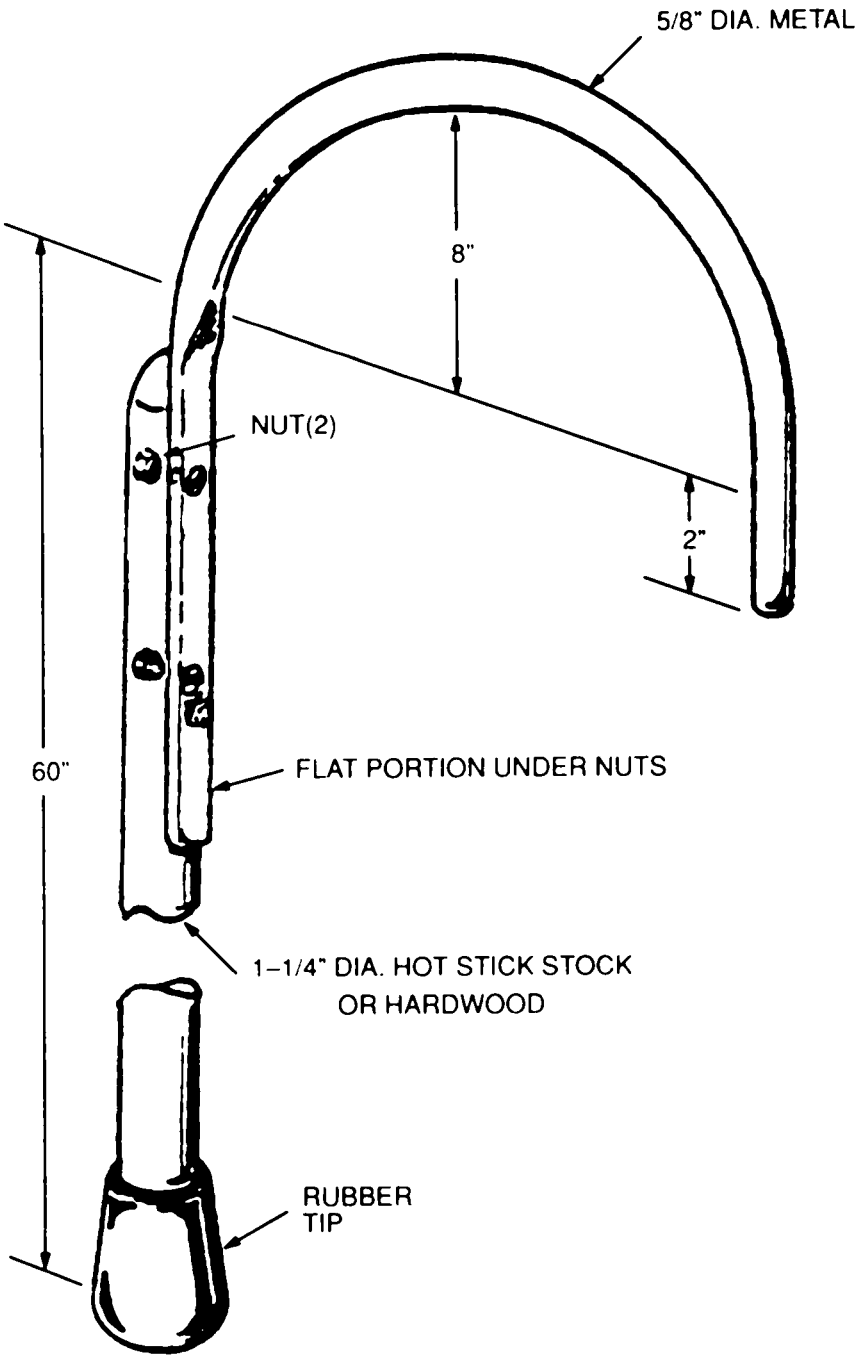

Figure 3-2. Hook, fabrication diagram

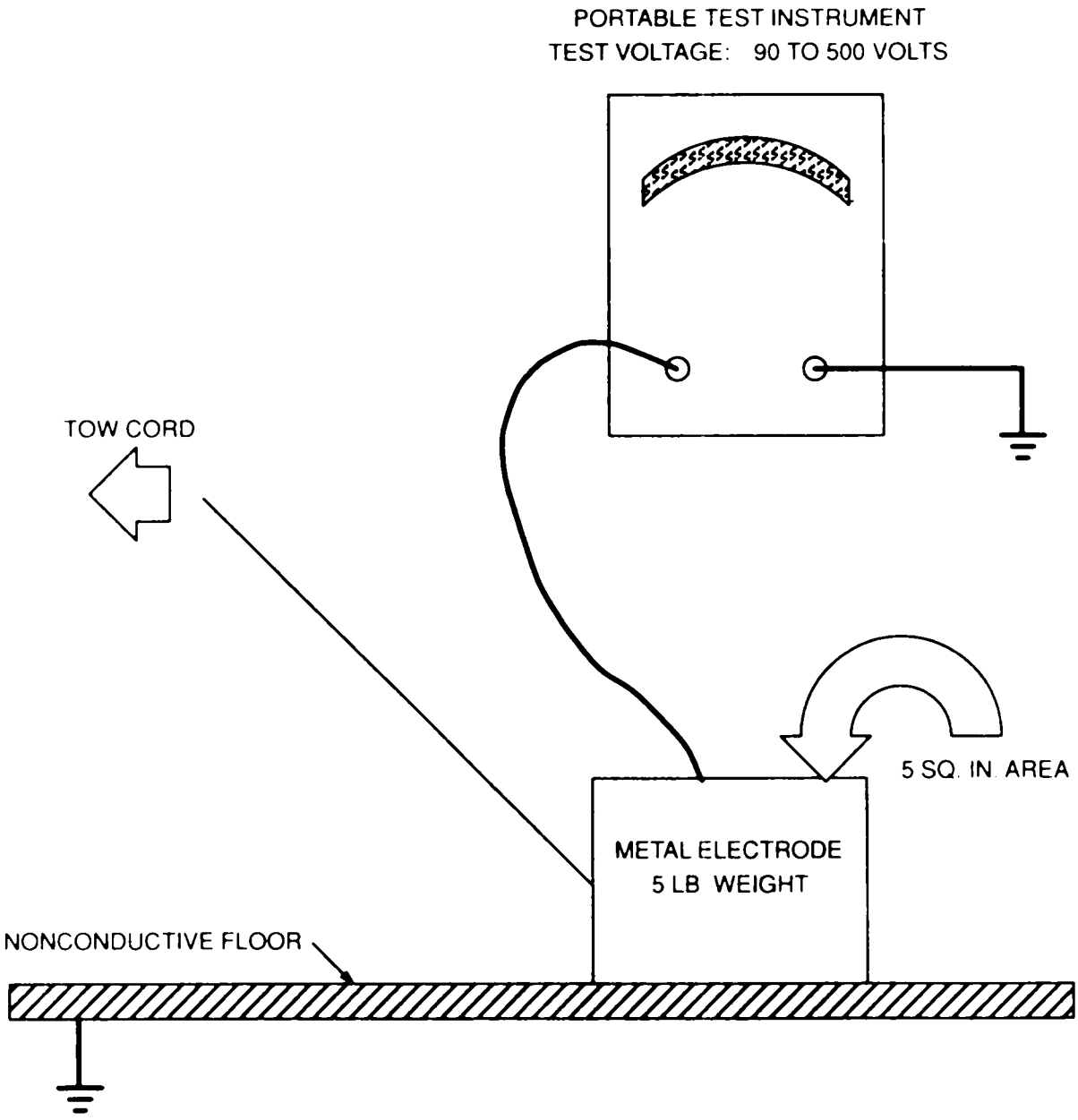

Figure 3-3. Testing insulating floors

Section IV. SAFETY REQUIREMENTS FOR ELECTROMAGNETIC EQUIPMENT

4-1. General

a. This section summarizes the essential safety responsibilities and precautions for maintaining equipments that generate energy in the electromagnetic spectrum. Electromagnetic equipments are those that emit non-ionizing radiation which includes ultraviolet, infrared and high--intensity visible light, including laser radiation, radiofrequency radiation (RFR): and X-radiation (X-rays). The safety requirements covered in Sections III and VI apply as well to electromagnetic equipment. Safety requirements for working near sources of ionizing radiation and handling radioactive material are covered in Section ''.

b. Responsibilities of the radiation protection officer and laser safety officers are explained in paras 4-2 and 4-3, respectively. Commanders' safety responsibilities for electromagnetic equipment maintenance are explained in para 4-1. Safety precautions to observe while maintaining various types of electromagnetic equipment are covered in paras 4-5 through 4-9 Para 4-10 provides medical guidance for injuries from nonionizing radiation.

4-2. Responsibilities of the Radiation Protection Officer (RPO)

The RPO is the principal overseer of radiation safety for the installation commander. He is responsible to:

a. Institute and enforce safety measures in the use or maintenance of equipments or components that emit either non-ionizing or ionizing radiation;

b. Discharge the responsibilities of the laser safety officer it no laser safety officer is assigned: see para 4-3.

c. Review and approve SOPs for the maintenance of equipment that emit RFR or X-radiation;

d. Inspect equipments and electronic devices that produce 10,000 volts or more for X-ray hazards; prescribe appropriate maintenance safety precautions such as the wearing of personnel dosimeters, installation of X-ray shielding. attachment of warning labels, etc.: and

e. Perform the safety functions pertaining to ionizing radiation that are listed in para 5-4.

4-3. Responsibilities of Laser Safety Officers (LSOs)

LSOs may be assigned to oversee the safety of laser maintenance operations for the installation commander. On those Installations where LSOs are not assigned, the RPO will discharge the LSO's responsibilities. These responsibilities are to:

a. Enforce laser safety;

b. Review and approve laser safety SOPs, including procedures for indoctrinating personnel and visitors In laser safety and for controlling access to laser maintenance areas and firing ranges;

c. Regularly inspect facilities that are used for firing of laser devices; and

d. Report laser accidents as required by Chapter 8 of AR 385-40 and Chapter 6 of AR 40-400.

4-4. Safety Responsibilities of Officials Who Exercise Operational Control Over Maintenance Activities That Service Electromagnetic Equipment

a. Commanders or other officials who exercise operational control over maintenance activities that service any type of electromagnetic equipment shall coordinate with the installation RPO and occupational health officer to determine the need to enroll specific personnel In medical surveillance programs, such as pre-placement and termination ocular examinations, biennial vision screening, or the wearing of personnel dosimeters. Policy for medical surveillance is expressed in DODD 6055.5-M and explained in TB MED 523 for RFR, TB MED 524 for laser radiation, and AR 40-5 for ionizing radiation.

b. Commanders or other officials who exercise operational control over maintenance activities that service or use high intensity light sources of the types identified in para 4-6 a shall post appropriate warning signs in work areas and publish a safety SOP. If the maintenance activity services air uses carbon arcs, the activity commander or responsible official, in consultation with the installation safety office. shall ensure that work areas are properly ventilated; ventilation requirements are explained in para 4-6 *b*.

c. Commanders or other officials who exercise operational control over maintenance activities that service laser equipment shall:

(1) Publish an SOP that (a) disseminates laser safety and first aid information as required by AR 405 and TB MED 524, and (b) identifies the maintenance activity's program for laser safety indoctrination and training;

NOTE

Information on first aid for use in laser SOPs is contained in Appendix G of TB MED 524.

(2) Ensure that all rooms that are used for firing of a Class 4 laser device have door interlocks that disable the laser firing mechanism until the doors are closed;

NOTE

Hazard classifications of laser devices are explained in para 4-7 *b*.

(3) Ensure that appropriate caution or danger signs are posted at the entrances to laser firing areas; fig. 4-1 is an example of a danger sign; (4) Ensure that laser maintenance facilities in which hazardous chemicals are used or stored contain an emergency eye wash and shower: the wash facility must be a type that can be easily operated by a blinded person and must function during the coldest time of year and it should be tested weekly; and (5) Ensure that maintenance facilities are adequately ventilated to exhaust (a) the gases from gas lasers or the by-products of laser reactions, such as bromine, chlorine, or hydrogen cyanide; (b) ozone created by laser-produced plasma; and (c) gases or vapors from cryogenic coolants.

d. Commanders or other officials who exercise operational control over maintenance activities that service radiofrequency (RF) equipment, such as radio transmitters and radars, shall:

(1) Publish an SOP that (a) identifies, to the extent practical, restricted areas around transmitting antennas, feed horns, open wave guides, and other radiating devices, and the necessary precautions for safe entry of personnel into these areas, and (b) describes the maintenance activity's program for RFR safety indoctrination and training;

(2) Ensure that all persons who are allowed access to areas where work is being performed on RF equipment are informed of RFR physiological effects and appropriate safety precautions: these are explained in paras 4-8 b and 4-8 d, respectively;

(3) Ensure that all conductive objects that are in RFR restricted areas, such as antenna masts and equipment shelters, are properly grounded: see para 7-2; and

(4) Report to the installation RPO or occupational health officer all incidents of actual or suspected RFR overexposures; see para 4-8 b.

e. Commanders or other officials who exercise operational control over maintenance activities that service or use X-ray equipment or equipments or electronic devices that produce 10,000 volts or more shall:

(1) Publish an X-ray safety SOP;

(2) Either verify that all such equipments and devices have been surveyed or arrange to have them surveyed to determine: (a) the extent of X-ray hazards, if

Figure 4-1. Class.3b or Class 4 laser controlled area warning sign

any; (b) need for personnel dosimeters as required by AR 40-14; and (c) need for attaching warning labels to the equipment, if any; and

(3) Implement, in coordination with the installation safety office, RPO, or industrial hygienist, appropriate X-ray safety measures, which might include posting of warning signs in the vicinity of X-ray hazards, installation of X-ray shielding, and the wearing of personnel dosimeters and instructions in their use.

4-5. Calibration of Infrared Equipment

When calibrating infrared equipment, observe the precaution explained in 4-6 *c,* in TFB N1FD 524, and in AR 40-46. Take care in working near moving mechanical parts. such as vane type choppers.

4-6. High-Intensity Light Sources

a. The following high-intensity light sources can cause eye damage hen directly or indirectly viewed. The damage that they produce is even more severe when they are used with collimating optics. The hazard becomes less obvious but no less dangerous. when the light is filtered to reduce the visible spectrum.

(1) Arc lamps (carbon. mercury. xenon, etc.)

(2) Common light bulbs (incandescent) rated 400 watts or more.

(3) Quartz lamps.

(4) Search light lamps

(5) Lamps used as infrared sources.

(6) Solar simulators.

(7) Arc welding equipment.

(8) Electric arc furnaces.

(9) Germicidal lamps and other ultraviolet sources.

b. Carbon arcs. which are used in welding and other applications, generate hazardous ozone and oxides of nitrogen which can cause headaches, vomiting, or, in severe cases. permanent lung damage, pneumonia, or death. areas in which carbon arcs are operated should be ventilated by at least 10 room air changes per hour. In addition. local exhaust ventilation of at least 100 feet per minute should be provided at the source of the hazardous gases. Because of the intensity of emitted radiation. safe operation of carbon arc equipment requires skin and eye protection.

c. High-intensity light safety precautions. Technicians and other personnel will observe the following precautions when maintaining an equipment or electronic component that produces high intensity light.

(1) Put on protective eyewear when working with a high intensity light source of any of the types identified fiedin paras 4-6 *a* (1) through (9) above. Be sure to select eyewear that (a) is designed to provide protection at the specific wavelength of the light with which you are working and (b) has an optical density no less than either that specified in the equipment technical manual or recommended by the installation safety office.

(2) Immediately stop viewing any light source that causes eye discomfort, whether or not you are using protective eyewear.

(3) Be especially alert when working with searchlights, welding machines. and other infrared light sources. You cannot see infrared light and it is hazardous.

(4) Before operating carbon arc equipment. be sure that both the room ventilation sand local exhaust fans are turned on and properly functioning.

(5) While working with carbon arc equipment, wear the personal protection equipment for your skin and eyes as specified in your SOP or by the installation safety office. Personal protective equipment for welding includes leather welder's gloves. leather apron, safety shoes. and a welder's helmet.

(6) Before operating equipment containing a high intensity light source of any of the types identified above in paras 4-6 *a* (1) through (9), make sure that warning signs are posted In the work area.

4-7. Lasers

a. Laser safety precautions are listed and explained in para 4-7 *c* below. These precautions are summarized from AR 405 and the hazard control measures contained in TB MED 524.

b. For the purpose of hazard classification, laser devices are designated as either Class 1, 2, 3a. 3b, or 4, which have the following characteristics.

NOTE

Details on laser hazard classification are provided in Appendix D of TB MED 524.

(1) Class 1 laser devices do not emit hazardous radiation.

(2) Class 2 laser devices, which emit visible light, are not hazardous when viewed for less than 0.25 second, but can cause eye injury to a viewer who continuously stares at the direct beam.

(3) Class 3a laser devices are normally not hazardous unless viewed with magnifying optics from within the beam.

(4) Class 3b laser devices are hazardous if the direct or specularly reflected beam is viewed by the unprotected eye.

(5) Class 4 laser devices present the same hazards as Class 3b devices and can also cause eye injury from diffuse reflections and produce fire and skin hazards. The hazard classification is labeled on the device's housing.

c. Laser Safety Precautions. Technicians and other personnel will observe the following precautions when working with laser devices.

(1) Check the operator's TM for specific safety precautions before operating any laser device.

(2) Do not view or visually align laser beams or aim laser beams toward people.

(3) Operate laser devices only in well-lighted rooms; good room lighting minimizes the opening of the pupil of the eye and reduces the potential for damage in the event of accidental exposure to the laser beam.

(4) Operate laser devices only for the minimum time necessary to perform tests. Use laser illumination only for the purpose for which it is intended. Never use laser light for general illumination.

(5) Before operating a laser device, make sure that the room is properly vented and that all ventilation and exhaust systems are properly functioning.

(6) Do not fire a laser upon any surface that can cause specular reflection, such as a mirrored, glass, chrome, or other shiny surface; reflected laser light can be as dangerous to the unprotected eye as a direct exposure. Make sure that screens used for laser testing have a diffuse matte surface, preferably painted black and lusterless. To the extent practical, keep the room free front dust or airborne particles and remove or cover reflecting surfaces such as brass door knobs, polished table tops, and glossy walls.

(7) Make sure that capacitors contained in laser devices are fully discharged before removing protective covers or panels. Be aware of the discharging method used in the device that you are maintaining; you can find this information in the equipment TM. These capacitors are normally designed to self discharge either by an interlocking relay attached to the access cover or panel or by the equipment's OFF switch. Never attempt to defeat the interlock or otherwise open the laser device while capacitors remain charged.

(8) Wear the proper protective masks or goggles whenever you are in the vicinity of an operating Class 3b or 4 laser device. For instructions in selecting protective eyewear, see Appendix F to TB MED 524 or consult your supervisor or the laser safety officer.

(9) Keep to a minimum the number of people occupying a room in which a Class 3a. 3b, or 4 laser device is being tested. Do not operate a Class 3b or 4 laser device until you are certain that all personnel and visitors in the room are wearing appropriate protective masks or goggles.

(10) Operate Class 3a. 3b, and 4 lasers only in a closed room or in a light-tight box. If practical, operate remotely so that no people need to be present in the room while the laser fires.

(11) Make sure that DANGER signs are posted near the door or entrance to a Class 3b or 4 laser firing area; consult your supervisor or the laser safety officer if signs are missing. An example is shown In fig. 4-1.

(12) Before operating a Class 3a, 3b, or 4 laser device outdoors or oil an indoor range which extends through areas of public access, make sure that the minimum distances and dimensions of the test range conform to para 3-29 *d* and fig. 3-10 of TB MED 524. If possible. conduct tests in unoccupied areas. If testing must be conducted in occupied areas, strictly control access to the range.

(13) Verify that caution or warning labels are permanently affixed to all Class 2 or higher laser equipment. If you receive any such laser equipment that does not contain a label. notify your supervisor or the laser safety officer.

(14) Before you work around hazardous chemicals with a Class 3b or 4 laser device, make sure that you know the location of the emergency eye bath or shower.

(15) While operating a Class 2 laser device, be careful to avoid direct eve contact with the beam.

(16) To avoid inadvertent ignition, use caution in operating Class 4 laser devices or power supplies around combustible solvents and materials. Be careful in storing and handling these solvents and materials.

(17) Do not handle cryogenic gas containers in any room where lasers are being tested. See para 6-2*c* for precautions on handling and storing pressurized gas cylinders and cryogenic gas containers.

4-8. Radiofrequency Radiation (RFR)

a. RFR safety precautions are listed in para 4-8 d below. These precautions are summarized from DOD Instruction (DODI) 6055. 11 and the RFR hazard control measures in TB MED 523.

b. DODI 6055.11 specifies a permissible exposure limit (PEL) to RFR within which it remains safe to operate and maintain RF equipment; conversely, exposure to RFR that exceeds the PEL can be hazardous. Excessive levels of RFR can cause localized heating of the skin. eyes. and other body tissue. The effects of prolonged exposure include eye cataracts and serious bums.

NOTE

The DoD-prescribed permissible exposure limit to RFR is 0.4 watts per kilogram of whole-body absorbed power averaged over any six-minute period.

c. People can ensure that they will remain within the PEL by keeping a proper distance of separation from the RFR source. Areas that are less than the minimum safe distance should be designated as restricted and placed off limits to personnel while RFR is present. Minimum safe distances of separation from RFR emitters in Army electronic systems and other important guidance are specified in the operator's TMs; for many systems, this information can also be found in TB 43-0133.

d. RFR *Safety Precaution.* Technicians and other personnel will observe the following precautions when working with an equipment or electronic component that produces RFR:

(1) Avoid unnecessary exposure to RFR. Operate transmitters and other sources of RFR only when necessary and at the minimum power and for the minimum period of time needed to maintain the equipment.

(2) Keep at least the specified minimum safe distance away from antennas and other RFR sources; consult the operator's TM to learn this distance; for many systems. you can also find this information in TB 43--0133.

(3) Continuously monitor unsecured restricted areas, *i. e.* any unsecured areas that are close: than the specified minimum safe distance from an RFR source, to ensure that no one enters.

(4) Be alert to the danger of shock and burns and keep your hounds and body away from unprotected transmitter output terminals, uninsulated RF transmission lines, antennas. and other devices that may be carrying RF energy. Shock or burns can be caused by RF energy at any frequency; however, they are most likely to occur at frequencies between 3 kHz and 100 MHz.

(5) Do not transmit RFR within buildings, equipment shelters, or other enclosed environments. Do not aim antennas or propagate RFR toward populated areas,. Except when it is necessary to test antennas, terminate RFR generators Into a dummy load or another closed system.

(6) Before transmitting RFR, inspect equipment interlocks and limiting and warning devices to make sure that they are properly functioning; If practical, make a record of the inspections. Observe the precautions in para 3-19.

(7) Before transmitting RFR. post warning signs to point out the location of restricted areas. Appropriate types and locations for warning signs are explained in AR 385-30 and TB MED 523. An example of an RFR warning sign is shown in fig. 4-2.

(8) Before transmitting RFR, make sure that all metal objects in the restricted area around the antenna are properly grounded, such as railings. antenna masts, and equipment shelters.

(9) If you inadvertently or otherwise enter a restricted or hazardous RF-R area, avoid contact with surrounding metal objects, such as railings, inactive antennas, equipment shelter walls, vehicles, aircraft, etc., whether or not such objects are grounded. Leave the restricted area as soon as possible and inform your supervisor and the RPO of the details of the overexposure.

NOTE

Grounding reduces but does not eliminate the risk of electric shock; see para 7-2.

(10) Disconnect power to the transmitter before inspecting antennas, feed horns, open waveguides. and the like. Before starting the inspection, take steps to prevent an inadvertent connection of RF power, such as tagging or preventing access to the transmitter and power supply.

(11) Before using any RFR-generating TMDE and shop equipment, such as signal generators. be sure that the interlocks and limiting devices contained therein are properly functioning.

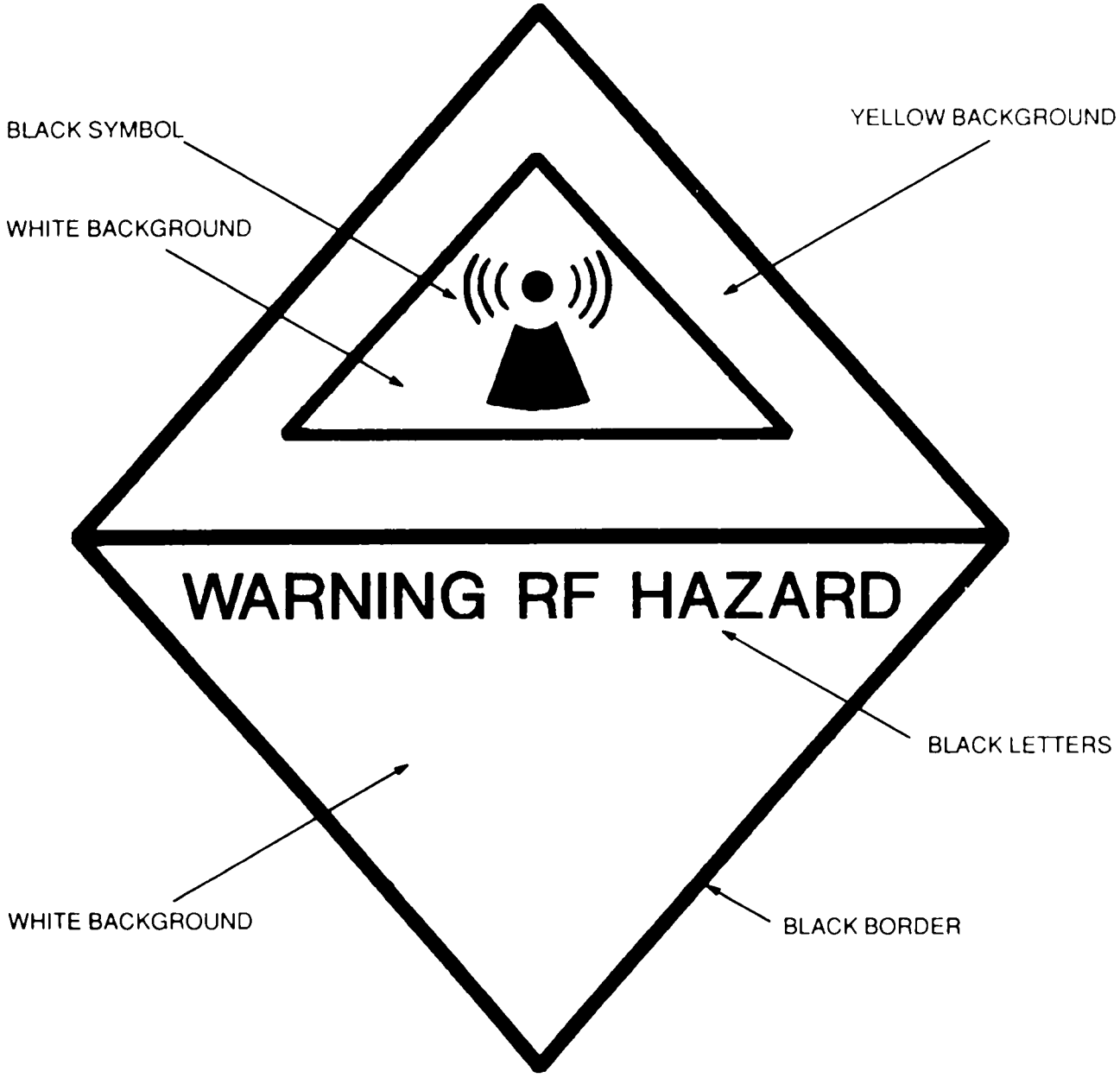

Figure 4-2. RFR hazard warning sign

(12) Before using installed waveguides of any kind, inspect for cracks and proper connections. If available, use an RFR leakage detector to check for leaks. (RFR leakage is more likely to occur in flexible waveguides than in rigid waveguides.)

(13) When maintaining electronics in an aircraft, make sure that the antennas are directed away from occupied areas before transmitting.

(14) Before erecting antenna masts, make sure that the clearance to nearby power lines is at lease twice the length of the mast.

(15) Before moving a vehicle, make sure that mounted whip antennas can clear power lines. If practical, remove or tie down the antennas before moving the vehicle.

4-9. X-Radiation

a. X-ray equipment, used in medical radiology and in some industrial applications, produces X-rays which can be hazardous. X-rays are also produced by electronic components that generate internal electron-beam voltages of 10,000 volts or more, such as magnetrons, klystrons, thyrations, and high-voltage rectifier tubes: these types of components are commonly found in radars and other devices. As the voltage of the electron beam source increases, the severity of the X-ray hazard and the degree of required protection go up as well. Exposure limits are specified In TB MED 521.

b. Excessive doses of X rays can cause cell abnormalities, eye cataracts, and cancer in the bone marrow. X-ray protection is provided by maintaining a suitable distance from the offending source, minimizing time of exposure, and shielding.

c. X-ray safety precautions. Technicians and other personnel will observe the following precautions when working with an equipment or component that produces X-radiation.

(1) Avoid unnecessary exposure to X--rays. Operate X-ray equipment and devices that emit X-rays only when necessary and at the minimum beam intensity and for the minimum period of time needed to perform the maintenance task.

(2) Wear personnel dosimeters when required by AR 40-14 or your activity's X-ray safety SOP.

(3) Before operating X-ray emitting devices, read and follow, your activity's X-ray safety SOP, the precautions in the equipment technical manuals, and the warning labels on the equipment.

(4) Be sure that adequate shielding is in place before operating or testing X-ray emitting devices on the bench. Consult your supervisor if you are not sure that the bench shielding is adequate.

(5) Be sure that interlocks and other safety features are properly functioning before operating the equipment.

(6) Do not bypass equipment interlocks when X- ray shielding is removed unless such bypass is specifically called for in the maintenance instructions. In such case, carefully follow the instructions to avoid exposure to hazardous levels of X-radiation.

(7) Replace all X-ray shielding before you leave the work area. The job is not complete until the shielding is replaced.

4-10. Medical Guidance for Injuries from Non-Ionizing Radiation

a. Radiation-induced eye injuries cannot normally be treated by first aid; examination and treatment of eye injuries may be performed only by medical professionals. Non-medical personnel should not attempt to treat the eye for radiation exposure, including laser discharges, regardless of the circumstances.

b. In the event of an actual or suspected injury from high intensity light, lasers. RFR. X-rays, or any other source of non-ionizing radiation. Supervisors or other responsible personnel will do the following.

(1) For non-ocular injuries, apply normal first aid; first aid information for common laser injuries is contained in FM 8-50. First aid for electrical shock is also explained in para 2-4.

(2) Whether or not pain is felt, obtain an immediate ocular examination by an ophthalmologist or optometrist for yourself or anyone whose eyes are exposed to high-intensity light, a Class 3a or higher laser discharge, RFR in excess of the PEL. or X-radiation. The examination should not be delayed more than 24 hours from the time of exposure. The sooner that necessary treatment is administered, the greater the possibility of minimizing eye damage. If in doubt about the severity of the exposure, seek an examination. Obtain medical attention following an accidental or unexpected laser discharge or whenever you are not sure whether the eyes were exposed to the beam.

Section V. SAFETY REQUIREMENTS FOR RADIOACTIVE MATERIAL

WARNING

IF A RADIOACTIVE ITEM IS BROKEN OR UNSEALED:

1. DO NOT TOUCH IT.

2. IMMEDIATELY CONTACT YOUR RADIATION PROTECTION OFFICER OR INSTALLATION SAFETY OFFICE TO OBTAIN NECESSARY PROCEDURES FOR SAFE DECONTAMINATION AND DISPOSAL OF THE RADIOACTIVE MATERIAL.

5-1. General

This section summarizes the principal radioactive safety precautions and handling and disposal procedures that are contained in AR 385-11. TM 3-261, and TB 43-0116. The safety requirements in Sections III and VI apply as well to radioactive equipment.

5-2. Policy and Procedures for Maintenance of Radioactive Equipment

a. Radioactive equipment may be maintained only on installations that are specifically authorized by AR 385-11 or a Nuclear Regulatory Commission (NRC) commodity license. Radioactive equipment will be handled only by authorized personnel.

b. Except for maintenance procedures that are specifically authorized in the equipment technical manuals, no diagnostics, disassembly, troubleshooting, or any other maintenance task or tampering of any kind is allowed on any equipment or component that contains radioactive material. Most radioactive components are non-repairable.

c. Exposure of radiation workers and other persons to radioactive material will be minimized. In no case will personal exposure to ionizing radiation exceed the limits specified in Title 10 CFR and AR 40-14. To maintain these limits, all persons, without exception, will wear personnel dosimeters when required by regulation, local policy, or SOP. A self-indicating pocket dosimeter may be used to supplement, but not to replace, the personnel dosimeter.

d. Persons under 18 years old or pregnant may not enter a radiation controlled area (RCA) under any circumstances. Other non-radiation workers and visitors may enter if and only if they are escorted by an authorized radiation worker.

e. Radiation workers with minor injuries. specifically cuts, abrasions. or open sores, must be cleared by the RPO before being allowed to work with any radioactive source; the RPO may impose restrictions on the work that any specific individual may perform. In all cases, the RPO must make his decision in conjunction with the NRC license manager and/or the safety office of the agency or command that supports the radioactive item of equipment (Defense Logistics Agency, CECOM, MICOM. etc.).

(1) *Sealed sources.* Sealed sources provide an extra degree of protection from the radioactive source. The RPO may clear an injured radiation worker to work with a sealed source, provided that his cut, abrasion. or open sore is covered by clothing. gloves, or other protective material.

(2) *Unsealed sources.* Because of the extra degree of hazard associated with unsealed sources. the RPO is required to obtain specific written permission from the license manager and the commodity agency before

permitting an injured radiation worker to work with an unsealed source.

f. While occupied, RCAs will be continuously monitored with a radiation survey instrument (radiacmeter), such as an AN/PDR-27 or equivalent. RCAs will be cleaned in a manner that minimizes airborne dust.

g. Food, water, or personal items may not be stored in any area that is used for the storage or maintenance of equipments that contain radioactive material.

h. The levels of ionizing radiation and airborne radioactivity in unrestricted areas that are used for storage of radioactive material shall not exceed the following limits:

(1) The radiation dose to the whole body shall not exceed 0.5 roentgen equivalent man (REM) in any one calendar year, 100 milliREMs in any seven consecutive days, or two milliREMs in any one hour if an individual were continuously present in the area.

(2) Airborne radioactivity shall not exceed 2 x 10^{-7} microcuries per milliliter (μCi/ml) from stored items containing tritium and 2 x 10^{-12} μCi/ml from stored items containing radium.

i. If a radioactive component or device becomes damage or broken and source material is unsealed, a responsible official or radiation worker on the scene will notify the installation RPO or safety office at once. The RPO or safety office will provide instructions for handling and disposing of the material and/or vacating the premises.

j. Non-repairable radioactive items that become defective will be handled as radioactive waste as prescribed in AR 385-11 and TM 3-261.

k. Tubes that contain radioactive material, which are normally identified and marked as such, will be handled as prescribed in TB 43-0116 and as follows:

(1) If breakage occurs, contact the installation RPO or safety office for instructions on handling and disposing of the material; see para 5-2*i*.

(2) If you find an unmarked tube (i.e., a tube without a radiation warning symbol) that you suspect might contain radioactive material, consult TB 43-0116 or the Army Master Data File to determine if it is a radioactive, consult the RPO for instructions on handling and marking it. Unless and until the tube is positively identified not to contain radioactive materials, handle and store it as if it were radioactive.

5-3. Safety Precautions

Observe the following precautions when maintaining any equipment or component that contains radioactive source material.

a. Do not enter an RCA if you are either under 18 years old or pregnant. If you have any cuts, abrasions, or open sores on your body, no matter how minor, be sure that you have been cleared by the RPO and all such injuries are covered with gloves or protective clothing before working with radioactive material, whether sealed or unsealed; see para 5-2*e*. If you have minor injuries and you are not sure whether it is safe for you to work, ask your supervisor.

b. MINIMIZE THE TIME that you occupy an RCA; stay in the area only for the time needed to perform the maintenance task. MAXIMIZE THE DISTANCE between your hands and body and the radioactive source; while you perform the task, remain as far away from the source as possible.

c. Wear your personnel dosimeter at all times when you are in an RCA that requires it. Be sure that your visitors, as well, wear personnel dosimeters.

d. Before starting work in an RCA, be sure that the ventilation system is properly functioning. Put on any gloves or protective clothing required by the SOP.

e. Before leaving an RCA, monitor your clothes and body for radiation contamination. If you are contaminated, clean and scrub your hands and nails and any exposed skin and follow the decontamination instructions in your SOP. See para 5-8.

f. Never deliberately expose radioactive source material. Never tamper with any equipment, component, or sealed container in any way that might inadvertently cause radioactive source material to become exposed. NO MAINTENANCE IS AUTHORIZED THAT REQUIRES OR ALLOWS RADIOACTIVE SOURCE MATERIAL TO BECOME EXPOSED.

g. Never carry a radioactive item in your pocket.

h. Never eat, drink, or smoke in an RCA. Never store food, drinks, tobacco, or cosmetics in an RCA.

i. Keep radiation work areas as clean as practical. However, use only the cleaning methods prescribed in your activity ‘s SOP.

j. Before handling a self-luminous device, become familiar with the safety precautions in TB MED 522.

k. If a radioactive component or device becomes damaged or broken and source material is unsealed, follow the instructions in para 5-2*i*.

5-4. Additional Responsibilities of the Radiation Protection Officer

In addition to the responsibilities listed in Section IV, the RPO shall:

a. Inspect and approve the use of facilities and SOPs that are to be used for handling of radioactive material;

b. Provide qualification training for radiation workers;

c. Oversee the handling and disposal of radioactive source material that accidently becomes unsealed and the decontamination or evacuation of the premises: and

d. Advise technicians and supervisors on the safe handling and maintenance of radioactive equipment and components. including the type and placement of radiation shielding, the marking and handling of unmarked radioactive tubes., and the laundering of radiation contaminated clothing.

5-5. Responsibilities of Officials Who Exercise Operational Control Over Maintenance Activities that Service Radioactive Equipment

a. The commander or other official exercising operational control over a maintenance activity will prepare and publish an SOP as explained in para 5-6.

b. Before allowing any radiation worker to handle radioactive equipments or components, the commander or other official who exercises operational control over a maintenance activity shall:

(1) Obtain verification from the installation RPO that the individual concerned has been properly trained to perform such maintenance and

(2) Indoctrinate the individual on the applicable safety precautions and handling restrictions that are contained in the DA Radiation Authorization, AR 385-11, TM 3-261, TB 43-0116, TB 43-0122, TB 43-0141, the NRC licenses, pertaining to the equipments under maintenance, and this bulletin.

c. The commander or other official who exercises operational control over a maintenance activity shall obtain facility approvals as explained in para 5-7.

5-6. SOP for Maintenance of Radioactive Equipment

Each maintenance activity that services radioactive equipment shall institute standard operating procedures that minimize the exposure of personnel to ionizing radiation. These procedures will be published in an SOP document, a copy of which will be posted at each location where radioactive equipment or material is handled. The following information should be included in SOPs.

a. Personnel safety indoctrination and training.

b. The safety precautions described above in para 5-3. Additional precautions may be included.

c. Location of all RCAs.

d. Where appropriate. methods for cleaning RCAs to minimize airborne dust.

e. Selection and proper use of gloves and protective clothing.

f. Equipment and methods for radiation monitoring and decontamination, including disposition of contaminated clothing. The procedures must comply with the Instructions for monitoring and decontamination that are contained in TM 3-261 and TB MED 522. If applicable, decontamination areas will be identified. See para 5-8.

g. Control, issuance, and wearing of personnel dosimeters for personnel and visitors.

h. First aid instructions for cuts or skin abrasions incurred while handling radioactive material and for inhalation or ingestion of radioactive material. The SOP will also contain instructions for notifying the installation medical authority in the event of such an accident.

i. Where applicable, instructions for operating RCA ventilation systems.

j. Instructions for reporting injuries, fires, explosions, and other incidents that involve radioactive material to the installation safety office.

k. Calibration and maintenance of radiation detection instruments.

l. Procedures for escorting non-radiation workers and visitors in RCAs.

5-7. Facility Approvals.

Prior to the first use and after each significant alteration or modification of any facility in which maintenance of radioactive equipment is to be performed. the installation RPO must inspect and approve the facility for such use. This inspection and approval will include a review of the following:

a. SOP, including procedures for personnel indoctrination and training;

b. Need for and the parameters of RCAs and decontamination areas;

c. Adequacy of facility's ventilation, where applicable.

NOTE

Ventilation must be adequate to maintain the concentration of airborne radioactive contamination below the limits specified In Title 10 CFR 20.

d. Type of gloves and protective clothing and equipment to be issued to personnel and the extent to which they must be used;

e. Signs and notices posted to comply with Title 10. CFR. AR 385 30. and AR 700-64. And

f. Suitability of installed radioactive shielding; if additional or replacement shielding is needed, the RPO will specify the appropriate type and placement.

5-8. Monitoring and Decontamination of Personnel

And individual will be monitored whenever he (a) leaves, an RCA or (b) handles a defective or broken radioactive item, regardless of the location. Contaminated persons should follow their SOP, for decontamination. as a minimum. SOPs will require cleaning and scrubbing of hands and nails and any exposed skin. If a person's clothing is contaminated above the limits permitted by AR 38511, he must immediately change: contaminated clothing should be either disposed as radioactive waste or laundered as stipulated in the SOP.

5-9. Instruments and Supplies for Radiation Detection

a. If required. maintenance activities that service radioactive equipment will requisition and maintain an adequate supply of personnel dosimeters to serve the needs of personnel and visitors. Identification of the types of personnel dosimeter available in the Army supply system and ordering instructions are contained in SB 11 206.

b. Self-indicating pocket dosimeters are available in the Army supply system.

c. Notwithstanding the calibration intervals recommended in TB 43-180, radiation survey instruments (radiacmeters) that are used for monitoring of radiation sources to protect the health and safety of personnel will be calibrated at least once every 90 days and immediately after they are maintained or their batteries are replaced.

5-10. Medical Attention and First Aid for Injuries that Involve Radioactive Material

As soon as possible after the occurrence of an accident or incident involving radioactive material, actual or suspected contamination victims should be examined by a physician. In the event of an injury, immediately contact the local medical authority, inform the physician of the type of radioactive material that is involved in the injury, and follow his instructions. Unless the physician directs otherwise, administer the following first aid while awaiting medical attention. Then, decontaminate The victim if his or her condition allows.

a. Small cut or puncture or skin abrasion: Wash the wound with a large amount of clean water. Then, allow it to bleed freely for a few seconds. Wash again and cover with a bandage.

b. Large cut or puncture: Place a large absorbent bandage over the wound and evacuate the injured person to a medical facility. The bandage should protect the wound from further contamination or infection, but should not be tightened to stop ordinary bleeding. If the injury causes arterial bleeding, indicated by the spurting of blood from the wound, then stop the bleeding, using a normal pressure bandage.

c. Contamination of the eye, nose, or mouth: Promptly rinse the affected areas with a large amount of clean water. If the nose is affected, have the contaminated person draw water from his cupped hand into his nostrils, blow it out, and repeat several times. Immediately after finishing the rinsing, take him to a medical facility. Persons whose eyes, nose, or mouth are affected should avoid swallowing until examined by a physician.

5-11. Reporting Fires, Explosions, Injuries, and Other Incidents Involving Radioactive Material

The installation safety office should be notified immediately following any incident involving radioactive material. Within 24 hours of its occurrence, the installation safety office should report the incident by telephone to the safety office of its next higher headquarters and to headquarters, US Army Material Command (AMCSF-P) at DSN 284-9340 or (703) 274-9340. The installation safety office will also prepare and submit a report of the incident on DA Form 285 and complete any other procedures that may be required by AR 385-40.

Section VI. OTHER SAFETY REQUIREMENTS

6-1. General

This section summarizes essential safety precautions not covered in the previous sections and requirements for storing hazardous and flammable materials and controlling acoustical noise while maintaining electrical and electronic equipments.

6-2. Safety Precautions

Technicians and other personnel will observe the following precautions when maintaining electrical and electronic equipment.

a. Acoustical noise. Keep acoustical noise levels and the time of exposure to high noises to a minimum. Wear the proper hearing protection device (HPD), earplugs and/or noise muffs, whenever you are in an area of high acoustical noise (85 dBA or greater). If you have not been provided with an HPD, ask your supervisor.

b. Mercury. Be careful to avoid breaking any component that contains mercury. such as switches. batteries, or thermometers. If there is a spill. do not touch or allow the mercury to contact any part of the body, mercury can cause headaches, nausea, diarrhea, and, in repeated or long-term exposure, loss of teeth and mental deterioration. Thoroughly wash your hands or any part of the body that may have inadvertently come in contact with the spilled mercury. If the skin becomes irritated and the irritation persists after washing, get medical attention. Immediately change any clothing that becomes contaminated. Contaminated clothing should normally be discarded; if it is to be laundered, special precautions are necessary to ensure that all the mercury is removed and to avoid contaminating other clothing or the laundry equipment; consult your installation safety office for further information. To minimize breathing of mercury fumes. stay out of the area of the spill until it is decontaminated. Contact the installation safety office to obtain instructions for decontamination.

c. Pressurized gas cylinders.

(1) Handle pressurized gas cylinders in accordance with Title 29 CFR 1910, Subpart M, and AR 700-68. Secure cylinders to avoid accidental tipping. Keep no more than two cylinders of the same gas at a work station at any one time. Remove the cylinders from the work station when they are empty; be careful when handling the empty cylinders as they may still contain a small amount of gas.

(2) Do not handle cryogenic gas containers in any room where lasers are being tested.

(3) Store cryogenic gas containers in open and well ventilated areas if possible. Check the container valves and seals regularly; suffocation can result from displacement of oxygen by leaking cryogenic gases. When you handle cryogenic gases, wear face shields, protective gloves, and three-quarter length smocks.

(4) All personnel who work with or handle pressurized gas cylinders will review AR 700-68 annually. Maintenance activities will maintain a record of these reviews.

d. Cleaning solvents. When cleaning equipment, consult the technical manual for the recommended type(s) of cleaning solvent, if any. Do not use highly toxic or flammable cleaning solvents that require special ventilation, such as carbon tetrachloride, trichloroethylene, and benzene. Do not use gasoline, benzene, ether, or any other type of flammable fluid to clean any type of electrical equipment. whether or not the equipment is connected to power. Likewise. do not use alcohol (unless specified by the equipment technical manual): it damages most types of insulating varnishes. Flammable materials that do not require special ventilation may be used to clean nonelectrical equipment; however, be alert to the danger of tire when using flammable materials in the presence of electrical generators or other equipment that can cause sparks and keep a safe distance away.

e. Compressed Air Blowers. Use either rubber or another insulating material for hose lines for blowing out equipment. Keep air supplies free of water. Keep air pressure to a minimum; do not allow it to exceed 30 pounds per square inch in any case. Do not use compressed air for cleaning floors. Do not blow compressed air onto any person, including yourself.

f. Foot Protection. When handling material that can injure your feet, wear safety shoes that meet ANSI Standard Z41. Approved shoe will have "ANSIZ41" labeled or embossed thereon. Your Installation safety office can recommend the appropriate type of safety shoes for your specific tasks.

6-3. Hazardous and Flammable Materials

Hazardous materials must be stored and handled in accordance with their Material Safety Data Sheets. Title

29 CFR 1910. DOD Manual 4145.19-R-1. and the applicable National Fire Prevention Association (NFPA) codes. Officials in charge of maintenance facilities must obtain the approval of the installation fire prevention officer before using or storing flammable materials, whether the materials are liquids, gases, or solids. Only the minimum quantity of flammable materials needed for immediate use should be stored at the maintenance facility. Store flammable material only in a cabinet of the type approved by the NFPA or in a flammable liquid store room that meets the requirements of Title 29 CFR 1910.106 and the NFPA Flammable and Combustible Liquids Code. Contact your installation safety office for specific information and guidance on these requirements.

6-4. Control of Acoustical Noise

Officials in charge of maintenance facilities must establish controls and procedures to minimize acoustical noise. They are responsible to ensure that persons who work in areas where the sound level is 85 dBA or greater are provided with hearing protection devices and receive pre-placement and periodic audiometric evaluations under the supervision of the installation medical authority. They must post warning signs In noise hazard areas to indicate that hearing protection is required.

Section VII. GROUNDING SYSTEMS AND FIRE PROTECTION

7-1. General

This section summarizes grounding and fire protection requirements for maintenance facilities.

7-2. Facility Grounding Systems

a. Facility grounding systems must be installed and maintained in accordance with recognized standards. The most authoritative and complete standard for grounding is the National Electrical Code (NEC). published by the National Fire Protection Association (NFPA) as NFPA Publication 70. (Copies of the NEC may be ordered from NFPA, P. O. Box 9101, Quincy, MA 02669-9101, telephone (617) 770-3000; payment is required.) Other sources for approved grounding techniques are MIL-HDBK-419A (Volume 2) and FM 11-487-4, both available through military publications channels.

b. All grounding points within a facility will be continuous to a grounding (earth) electrode. The resistance measured from the facility's most remote grounding point to each electrode should not exceed twenty-five ohms.

c. Mobile facilities will be grounded as follow:

The vehicle will be grounded to a ground rod or an equivalent grounding system.

(1) If used, the power generator will be grounded to a ground system. If the generator and vehicle are sited less than twenty-five feet apart, either a common ground will be used or the two ground systems will be connected with bare copper cable, AWG #6 or larger.

(2) If commercial power is used, the vehicle will be grounded to the commercial ground conductor at the first service disconnect.

d. Metal frames of electric equipment and tools., such as handheld power tools, must be connected to a grounding conductor. *i.e.*, they must contain a three wire power cord and plug. Portable tools that are protected by an approved insulation system (Underwriter's Laboratory, or equivalent) need not be grounded.

e. Maintenance activities will maintain a file of up to-date descriptions of all facility grounding installations, such as construction specifications and drawings. blueprints, work orders, etc. Installation engineers or other qualified personnel (as determined by local policy') should annually inspect grounding systems for compliance with appropriate standards, including conductor continuity as described in para 7-2 *b.* Continuity inspections should be made with a low-resistance ohmmeter.

7-3. Fire Protection

a. In the event of fire:

(1) Kill the power to all circuits in the affected area.

(2) Call the installation fire department.

(3) To the extent that it is safe, control tile fire until the firefighters arrive. If the fire is electrical. use only a type of fire extinguisher that is rated for Class C fires; see para 7-3 *b.* Do not use soda acid, water, or foam extinguishers on electrical fires; water and foam are conductive and can cause electrical shock.

b. Facilities will maintain fire extinguishers that are rated for Class C fires. To ensure that fire extinguishers are maintained in proper working order, each facility will establish a program of regular inspection in coordination with the installation fire department.

Appendix A
REFERENCES

10 CFR	Energy (Code of Federal Regulations. Title 10)
29 CFR	Labor (Code of Federal Regulations, Title 29)
DODD 6055.5-M	Occupational Health Surveillance Manual
DODI 6055.11	Protection of DoD Personnel from Exposure to Radiofrequency Radiation
MIL-HDBK-419A	Grounding, Bonding, and Shielding for Electronic Equipments and Facilities
AR 40-5	Preventive Medicine
AR 40-14	Control and Reporting Procedures for Exposure to Ionizing Radiation and Radioactive Materials
AR 40-46	Control of Health Hazards from Lasers and Other High-Intensity Optical Sources
AR 40-400	Patient Administration
AR 385-9	Safety Requirements for Military Lasers
AR 385-11	Ionizing Radiation Protection (Licensing, Control, Transportation, Disposal, and Radiation Safety)
AR 385-30	Safety Color Code Markings and Signs
AR 385-40	Accident Reporting and Records
AR 700-64	Radioactive Commodities in the DoD Supply System
AR 700-68	Storage and Handling of Compressed Gases and Gas Cylinders
FM 8-50	Prevention and Medical Management of Laser Injuries
FM 21-11	First Aid for Soldiers
FM 11-487-4	Installation Practices: Communications Systems Grounding, Bonding, and Shielding
TB MED 521	Management and Control of Diagnostic X-Ray, Therapeutic X-Ray, and Gamma-Beam Equipment
TB MED 522	Occupational and Environmental Health: Control of Health Hazards from Protective Material Used in Self-Luminous Devices
TB MED 523	Control of Hazards to Health from Microwave and Radio-Frequency Radiation and Ultrasound
TB MED 524	Occupational and Environmental Health: Control of Health Hazards from Laser Radiation
TB 43-180	Calibration and Repair Requirements for the Maintenance of Army Material
TB 43-0116	Identification of Radioactive Items in the Army
TB 43-0122	Instructions for the Safe Handling and Identification of US Army Communications-Electronics Command-Managed Radioactive Items In the Army Inventory
TB 43-0133	Hazard Criteria for CECOM Radiofrequency and Optical Radiation Producing Equipment
TB 43-0141	Safe Handling, Maintenance, Storage, and Disposal of Radioactive Commodities Managed by the US Army Troop Support and Aviation Materiel Readiness Command
TM 3-261	Handling and Disposal of Unwanted Radioactive Material
SB 11-206	Personnel Dosimetry Supply and Service for Technical Radiation Exposure Control
ANSI Z41	Personnel Protection: Protective Footwear
ANSI Z358.1	Emergency Eyewash and Shower Equipment
NFPA 30	Flammable and Combustible Liquids Code
NFPA 70	National Electrical Code

Appendix B
LIST OF ACRONYMS AND ABBREVIATIONS

AC	alternating current
ANSI	American National Standards Institute
AR	Army Regulation
AWG	American wire guage
Ci	curie
CECOM	U.S. Army Communications-Electronics Command
CFR	Code of Federal Regulations
CPR	cardiopulmonary resuscitation
CRT	cathode ray tube
DA	Department of the Army
dBA	A-weighted decibels
DC	direct current
DOD	Department of Defense
DODI	Department of Defense Instruction
DSN	Defense Switched Network
FM	Field Manual
GFCI	Ground Fault Circuit Interruption
HPD	Hearing Protection Device
Hz	hertz
LSO	laser safety officer
ma	milliamperes
MACOM	major Army command
MICOM	U.S. Army Missile Command
MIL-HDBK	Military Handbook
ml	milliliter
NEC	National Electrical Code
NFPA	National Fire Protection Association
NRC	Nuclear Regulatory Commission
NSN	National Stock Number
para(s)	paragraph(s)
PEL	permissible exposure limit
RCA	radiation controlled area
REM	roentgen equivalent man
RF	radiofrequency
RFR	radiofrequency radiation
RMS	root mean square
RPO	radiation protection officer
SB	Supply Bulletin
SOP	standard operating procedure
TB	Technical Bulletin
TM	Technical Manual
TMDE	Test, measurement, and diagnostic equipment

By Order of the Secretary of the Army:

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General, United States Army
Chief of Staff

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Secretary of the Army
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THE METRIC SYSTEM AND EQUIVALENTS

'NEAR MEASURE

. Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches
1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches
1 Kilometer = 1000 Meters = 0.621 Miles

'VEIGHTS

Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces
1 Kilogram = 1000 Grams = 2.2 lb.
1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces
1 Liter = 1000 Milliliters = 33.82 Fluid Ounces

SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches
1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet
1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches
1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

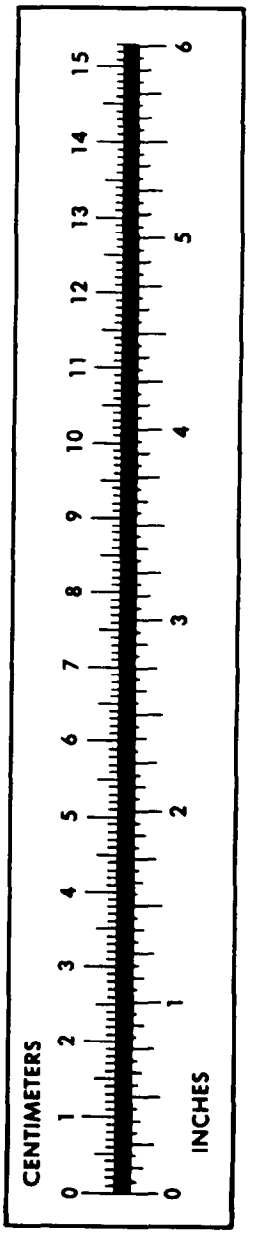
TEMPERATURE

5/9(°F - 32) = °C
212° Fahrenheit is evuivalent to 100° Celsius
90° Fahrenheit is equivalent to 32.2° Celsius
32° Fahrenheit is equivalent to 0° Celsius
9/5C° + 32 =°F

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
ıts	Liters	0.473
arts	Liters	0.946
allons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds per Square Inch	Kilopascals	6.895
Miles per Gallon	Kilometers per Liter	0.425
Miles per Hour	Kilometers per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
ers	Gallons	0.264
ms	Ounces	0.035
ograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pounds-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
lometers per Liter	Miles per Gallon	2.354
meters per Hour	Miles per Hour	0.621



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